Astronomy 100 - Exploring the Cosmos

Fall Semester 2012

Cosmic Time & Distance

Overview of the Course

Astronomy 100 is a seminar course primarily intended for first year undergraduate students interested in science or engineering, and particularly recommended for those potentially interested in astronomy and astrophysics. However, the course is designed to be accessible to all students, and all students are welcome. The theme changes from time to time, selected from among topics of modern cosmic physics with the aim of introducing important concepts, methods and discoveries interesting to a wide range of students. The topic for fall 2012 is *Cosmic Time & Distance*.

Overview of the Fall 2012 Semester Topic

Earth formed about 4.54 billion years ago (a time interval thought to be known to within about 1%), contemporaneously with the Sun, and about 9 billion years after what is thought to have been the formation of our universe. Life apparently developed on Earth between 3½ and 4 billion years ago, remarkably soon after the formation of our planet. Abundant, multicellular, "large", extravagantly fossil-leaving, hard-shelled organisms are found dating back to some 540 million years before the present. (Some consensus accounts suggest that date as 542 ± 0.3 million years ago, a level of formal precision that, itself, almost invites discussion.) Early dinosaurs appeared about 230 million years ago, had developed into the dominant large terrestrial life form by about 200 million years ago, and suddenly became extinct about 65.5 million years ago (except for some of the smaller species that escaped the extinction event and evolved into what, today, we call birds). The early erect primate ancestors of humans probably appeared on Earth over a period of time between 5 and 7 million years ago, an uncertainty driven to a large extent by the sparseness of the still-to-be-fully-recovered fossil record, as well as by definitional ambiguities inherent in marking certain specific transitions in a more or less continuous evolutionary development. Modern humans evolved slowly from those hominid ancestors during the time since, and had begun to develop recognizably modern urban-concentration lifestyles by about 10,000 years ago.

In spatial dimensions, we know that our Sun, which Earth orbits at a distance of about 93 million miles, is a star situated in an otherwise undistinguished location near the periphery of the Milky Way Galaxy. The Galaxy, while it lacks sharp boundaries, has a visible part, much of which is shaped more or less like a disk some 600 quadrillion miles across, and 6 quadrillion miles thick. In addition to our Sun, the Milky Way Galaxy contains around 200 billion other stars, the next nearest of which is 25 trillion miles from here. The part of the universe we can see contains about 100 billion other galaxies at vast distances and separations that we can generally and approximately ascertain.

None of these facts of time and distance is derivable from any witnessed primary record. Yet, these facts define the main temporal and spatial context of our existence. Without the power to tell time and distance beyond immediate and recorded human experience we would be deprived of knowledge of most history and geography – and, thus, of our broadest sense of human context. The same physics and chemistry that reliably gives us modern technologies, remarkable new materials and devices, and unprecedented medical therapies, also gives us the ability to analyze a rock and read from its inside that it is 3½ billion years old, or to analyze a piece of charcoal and ascertain that it is the remnant of a fire that burned 9,000 years ago. At the same time, astronomers, applying a long series of discoveries and advances, have learned to measure distances to objects far beyond our direct reach.

This course explores how scientific investigation is able to establish the scales of deep space and deep time, thereby delineating the cosmic stage upon which our existence plays out. Ascertaining these scales of time and space has consumed (and continues to consume) the efforts of numerous investigators over several centuries, with extraordinary advances during past 100 years. These investigations draw from a range of scientific disciplines. The objective of this course is that students come away with a general understanding of how we are able to ascertain these basic facts about our world.

Instructor

Eugene H. Levy

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Time & Place

Thursdays | 4:00 - 5:00 PM | Hermann Brown Hall 453

Prerequisites

There are no prerequisites for this course, and efforts will be made to ensure that the course material is accessible to all students. Techniques for measuring time and space do draw on elementary aspects of simple geometry, basic properties of radioactive elements, rudimentary concepts of chemistry, and the like ... all of which should be either known to, or readily accessible to, Rice students.

Class Structure

This seminar course meets one hour per week. As a seminar, this course entails high degrees of student participation. Much of the in-class time will be devoted to prepared student presentations of the material

accompanied by intensive class discussion. These presentations are expected to be well prepared and illustrated; PowerPoint capability will be available and students should plan on availing themselves of that resource. Class material will be drawn from the text(s), from other published literature, and from the web. Occasionally the instructor may need to be absent for an out-of-town meeting; on such occasions a guest lecturer or instructor may be invited.

Text & Materials

The course will, in addition to other other library and online sources, draw heavily on the material from:

The Age of Everything **[H]**
Matthew Hedman / University of Chicago Press © 2007
[Also available as a digital eBook. At the time this syllabus was prepared, the digital edition of this book was listed at an extraordinarily attractive price by a major online book vendor.]

~~The second part of the course will, also in addition to other sources, draw heavily on material from:~~
~~Measuring the Universe: Our Historic Quest to Chart the Horizons of Space and Time [F]~~
~~Kitty Ferguson / Walker & Co. © 2000~~

In preparing presentations or further pursing topics of special interest to them, students are encouraged consult other source material. Numerous sources in the library or on the web will be helpful as well. Some topics covered in this class are subjects of controversy, particularly at the boundaries of scientific and religious discourse. Students should approach reference materials with a critical eye, whether in the library on on the web, but especially on the free-for-all web. The following are very nice books, though they tend to be a bit deeper in the (sometimes somewhat technical) details that I was hoping to circumvent in this seminar, which is aimed at underscoring the simplicities that underlie the measures of cosmic time and distance.

The Age of Earth, by G. Brent Dalrymple
Stanford University Press © 1994

Physics of the Earth and Planets
A. H. Cook / Halstead © 1973

Ancient Earth, Ancient Skies: The Age of Earth and its Cosmic Surroundings
by G. Brent Dalrymple / Stanford University Press © 2004

How Old is the Universe.
David A. Weintraub / Princeton University Press © 2010
[Also available as an eBook in several formats.]

Measuring the Universe The Cosmological Distance Ladder
Stephen Webb / Springer Praxis Books © 1999

Additional reference sources may be linked from a "Resources, et cetera" section on the class website.

Class Website

Class Website Linked From: http://ehl.web.rice.edu/
Students are responsible for being familiar with the content of this syllabus as well as the content of the website, which may evolve during the semester. Any updates to this syllabus will be available on the website.

Topics to be Covered

The table shows the roughly anticipated class-subject schedule based on 13 class weeks beyond the first week.

Week	Topic	Reading Chapter(s)	Date	Discussion Leader
1	**Introduction and organization of the class**	H-1,2,3	Aug 23	Levy
2	**Time Introduction: Aspects of radioactivity & chemistry**	—	Aug 30	Levy
3	Historical and human-prehistoric time: Carbon-14 clock	H-4	Sep 6	Levy
4	Calibrating and using C-14 clock Kinds of things learned? / Limits of applicability?	H-5,6	Sep 13	**Cheemerla**
5	Clocks for geologic time: potassium-argon; rubidium-strontium, etc.	H-7	Sep 20	**Lerma**
6	The formation age of Earth Meteorites & other indicators of Earth's age	H-9	Sep 27	**Koonce**
7	Short time differences long ago: aluminum-magnesium clock, etc. Distinguishing the order of closely spaced events in the distant past?	H-9	Oct 4	**Bessette**
8	**Distance Introduction: Aspects of geometry & light**	—	Oct 9	Levy
9	No class this week - Outside assignment to choose topic for final paper	H-10,11	Oct 18	—
10	More distant stars & nearby galaxies: brightness of variable stars	Resources, etc	Oct 25	**Naticchia**
11	Distant galaxies: finding other brightness signposts	Resources, etc	Nov 1	**Hogg**
12	Connecting time, distance and age of universe: Hubble Relationship	Resources, etc	Nov 8	**Ovalle**
13	Best distance signposts: supernovae and the "fate" of the universe	Resources, etc	Nov 15	**Bailey**
14	**Wrap-up discussion: Our position in time and space**	—	Nov 29	Levy

Potential Syllabus Changes

This syllabus is intended to convey a general overview of the course content, expectations, practices and policies. The list of topics and timings given above will likely be adjusted as the course proceeds. The syllabus is subject to minor alteration in other respects as deemed appropriate by the instructor. If alterations are made, students will be given reasonable advance notice in class and on the class website. The policy on absences will not change.

Grading

Final grades will be based 60% on class participation including (individual or group) presentations, and 40% on a final individual paper.

Class Attendance

Students are expected to be present for all classes. Inasmuch as this is a seminar class, the final grade will depend especially strongly on participation, for which, generally speaking, presence is a necessary but not sufficient condition. Students with circumstances unavoidably affecting their attendance – including formal athletics commitments – should consult with the instructor well before their attendance is compromised.

Honor Code, Collaboration & Citation Policies

In preparing class presentations, whether individual or collaborative, students may consult any materials and discuss freely with others. In preparing the final class paper, students may again consult any materials of their choosing, and freely engage conversations. However, the writing of the paper is to be the sole and individual work of the student, and subject to the Rice Honor Code. In all work, students are expected to be scrupulous about proper citation of sources, as required both as a matter of integrity and formally as a part of the Rice Honor Code. Violations of the Honor Code are judged by the independent student-run Rice Honor Council, which has the responsibility to adjudicate infractions such as cheating, plagiarism, and other forms of academic misconduct, and imposes heavy penalties when it deems that appropriate.

Machines in the Classroom

Cell phones must be turned off – or rendered silent and ignored – within the classroom. Laptops or other small devices may be used only for specific class purposes such taking notes or in support of presentations.

Disabilities & Accommodations

Rice University and the instructor are committed to providing an environment of broad access and feasibly equal opportunity to education. The University's Disability Support Services Office (DSS; Allen Center, Room 111; 713-348-584; adarice@rice.edu) supports and implements federal guidelines under the Rehabilitation Act of 1973 and the Americans with Disabilities Act. Students with documented disabilities requiring accommodation under Rice's established policies should consult DSS and the instructor; all such consultations and accommodations will be held confidential to the extent feasible.